IS 7326-1 (1992): Penstock and turbine inlet butterfly valves for hydropodwer stations and systems, Part 1: Criteria for structural and hydraulic design [WRD 12: Hydraulic Gates and Valves]

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(Reaffirmed 2002)

भारतीय मानक

पन बिजली घरों तथा तंत्रों के लिए (पेनस्टाक) तथा टरवाइन के अन्तर्गत् के बटरफ्लाई वाल्वों – विशिष्टि

भाग 1 संरचनात्मक और जलीय डिजाईन की कसौटी

(पहला पुनरीक्षण)

Indian Standard

PENSTOCK AND TURBINE INLET BUTTERFLY VALVES FOR HYDROPOWER STATIONS AND SYSTEMS

PART 1 CRITERIA FOR STRUCTURAL AND HYDRAULIC DESIGN

(First Revision)

UDC 621·646·25 : 627·844 : 621·224-225·12

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

October 1992 Price Group 4

Hydraulic Gates and Valves Sectional Committee, RVD 12

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydraulic Gates and Valves Sectional Committee had been approved by the River Valley Division Council.

The butterfly valve is one of the types of shut-off devices most commonly employed in hydropower station and systems. Its use is favoured because of their relatively low cost, compactness, light weight, reasonable water tightness and simplicity of operation.

Basically, butterfly valve consists of a circular, lens shaped or open frame moving disc and body. The disc is pivoted in the body by two turnnions. When open the plane of symmetry of the disc lies parallel to the penstock axis.

It serves the following purposes:

a) Stops the water flow to the turbine when the latter is stopped and when no water is to be allowed to flow through the guide vanes.

b) Stops the water entry in case of emergency, that is, non-closure of guide apparatus or in the event of low oil pressure in the system.

c) Unit isolation in multi-unit plants where one penstock feeds more than one unit.

d) To facilitate inspection of water path passage.

e) To close the valve in the event of penstock rupture. In case of turbine inlet valve, valve should close in the event of over velocity due to the turbine trip or rejection of load.

This standard covers only the general principles of design of valves so as to permit necessary flexibility in their detailed design by various agencies in the country.

This standard is being published in three parts. Part 1 deals with the structural and hydraulic aspects of design. Part 2 deals with the guidelines for design and selection of control equipment used in butterfly valves. Part 3 deals with the operation and maintenance of butterfly valves.

This standard (Part 1) was first published in 1974. A revision of the standard has been taken up to incorporate certain changes found necessary in the standard in the light of comments received from the users. The major changes in this revised standard are sizes of 400 mm - 1 100 mm of butterfly valves have been added and one more type of shape of disc has been added. Further bearing stress has been increased to 350 kg/cm^2 instead of 320 kg/cm^2.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed of calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PENSTOCK AND TURBINE INLET BUTTERFLY VALVES FOR HYDROPOWER STATIONS AND SYSTEMS

PART 1 CRITERIA FOR STRUCTURAL AND HYDRAULIC DESIGN

(First Revision)

1 SCOPE

This standard (Part 1) applies to reinforced solid rubber resilient sealing, rust resisting steel seated, double-flanged butterfly valves and lays down the criteria for the structural and hydraulic design of butterfly valves for penstock and turbine inlet valve applications.

2 REFERENCE

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 TERMINOLOGY

3.0 For the purpose of this standard the following definitions shall apply.

3.1 Double-Flanged Valves

Valves which are having flanges at either end and having bolts at each flange.

3.2 Low Leakage Rate Valve

A valve which has an agreed amount of leakage in the closed position.

4 STANDARD SIZES

4.1 Butterfiy valves may be made as far as possible in the following standard nominal diameters (in mm):

400, 500, 600, 700, 800, 900, 1 000, 1 100, 1 200, 1 300, 1 400, 1 500, 1 600, 1 700, 1 800, 1 900, 2 000, 2 100, 2 200, 2 300, 2 400, 2 500, 2 600, 2 800, 3 000, 3 200, 3 400, 3 600, 3 800, 4 000, 4 200, 4 500, 5 000, 5 500, 6 000, 6 500, 7 000, 7 500, 8 000.

5 MATERIAL

The material recommended to be used for different components is given in Annex B.

6 PERMISSIBLE STRESS LEVELS

6.1 The maximum permissible stress levels at the design head for the materials used are:

a) *Steel*

Tensile stress = 0·25 of ultimate tensile stress or 0·5 of yield strength whichever is less.

Shear stress = 0·35 YP

b) *Bronze*

Bearing stress = 0·035 UTS.

7 DESIGN OF MECHANICAL PARTS

7.1 Valve Body

7.1.1 The valve body should be cast, cast fabricated or fabricated from materials as recommended in Annex B. The body should have two hubs for trunnion bearing housings. Flanges for connecting to penstock should be at right angles to the axis of the bore and concentric with the bore and the faces should be parallel. Where design does not permit the use of through bolts, the valve flange may have tapped holes.

7.1.2 The body may be made in a single piece or in parts for convenience of manufacture, transport to site and erection. The body should be stress relieved before any machining is done.

7.1.3 The fasteners of parting flanges and two end flanges should be tightened with specified initial tightening by heating or by slogging to have controlled total stresses developed in the fasteners. The fastners should be of corrosion resistant steel, otherwise they should have corrosion resistant coating.

7.1.4 In case of butterfly valves used as a turbine inlet valve, the body should be designed to avoid abrupt changes in velocity. Water passage may be so shaped so as to give either constant velocity or to give a gradual increase in velocity in the direction of flow. Minimum loss of head should be kept in view while designing.

7.1.5 The shell of the body should be designed such as to sustain maximum static head including pressure rise. Supporting feet for installing the valve on its foundation should be provided. These feet or part, thereof, are to be integral with the valve body, and should not extend beyond the flange faces of the valve. These supporting feet should have holes bigger than the diameter of foundation bolts to allow for axial movement of valve thus avoiding axial load on foundation.

7.1.6 Suitable means of adequate strength for lifting the valve should be provided.

7.2 Valve Disc

7.2.1 The design of all types of discs should be such as to offer minimum head loss in the open position and to sustain the full differential pressure across the closed valve.

7.2.1.1 The valve disc should be cast, cast fabricated or fabricated from the materials as recommended in Annex B. The disc may be split in parts for ease of manufacture, transport and erection. Disc should be stress relieved before taking up for machining operation.

7.2.2 The disc should be of any of the following shapes:

a) *Symmetrical disc* — This is of good hydro-profile construction having seal elements which follow an irregular periphery, being diverted around the spindle (*see* Fig. 1).

b) *Lattice disc* — The lattice disc basically consists of a sealing plate and a bridge joined by integral cast or cast fabricated shafts and a central web. The profile and shape of the openings should be so arranged that they offer least resistance to flow (*see* Fig. 2).

c) *Unsymmetrical disc* — This is of plano convex type having good hydro-profile with off-centre circular seal (*see* Fig. 3).

d) *Parallel face disc* — This is a cylindrical disc having uniform thickness and to be used with inlet and outlet fixed flow guides. The usual shape should be adopted for parallel face construction (*see* Fig. 4).

e) *Double seal parallel face through flow (lattice) disc* — This is a through flow (lattice) type disc consisting of two sealing plates, one may be used for manually operated metallic seal and other one for reinforced fibre solid rubber seal, joined by integral cast or cast fabricated shafts and central webs. The profile and shape of the openings be so arranged that they offer least resistance to flow (*see* Fig. 5).

7.2.3 The angular travel of disc should be nearly 90° from open to shut-off position.

7.2.4 Thrust collar should be provided to hold the disc in the centre of valve body.

7.3 Valve Trunnions

7.3.1 Valve trunnions should be of either one piece unit extending completely through the disc or of the stub type comprising two separate trunnions in the valve disc hub. In case of lattice constructions trunnions should be integrally cast with the disc or cast welded. Trunnions should be made from material recommended in Annex B.

7.3.2 Trunnion may be mounted in horizontal or vertical positions depending upon the requirements. It is preferred to have trunnions off centre to body centre to get advantages during closing.

7.3.3 The design of trunnions should be such that it will safely sustain maximum differential pressures across the closed valve. The trunnion and any keys or dowels, etc, used for transmitting the torque between trunnion and disc, should be capable of withstanding the maximum torque required to operate the valve. The trunnion should also be designed for the stress developed during valve closing under emergency condition and over velocity or penstock rupture condition.

7.4 Bearings

7.4.1 Valves should be fitted with sleeve type bearings or self-centering bearing, where required, contained in the hubs of the valve body. It should be suitable for the maximum load imposed by the trunnion. Bearings should be made from material recommended in Annex B.

7.4.2 Suitable provision should be made for lubrication of the bearings, unless the bearings are of the self lubrication type.

7.5 Seal

7.5.1 The seal is of fibre reinforced solid rubber type. When seals are adopted for upstream and downstream faces the upstream seal should preferably be of metallic type using corrosion resistant steel and should be manually operated.

7.5.2 Seal should be designed to provide tight shut-off or to an specified amount of leakage at the maximum working pressure, or at a pressure to be specified by the purchaser. For the maximum permissible leakages refer to Annex C.

7.5.3 The seal should be securely attached either to the body or to the disc.

7.5.4 The material used should be compatible with the temperature and characteristics of the fluid for which the valve is supplied. Seal should be made from material Annex B.

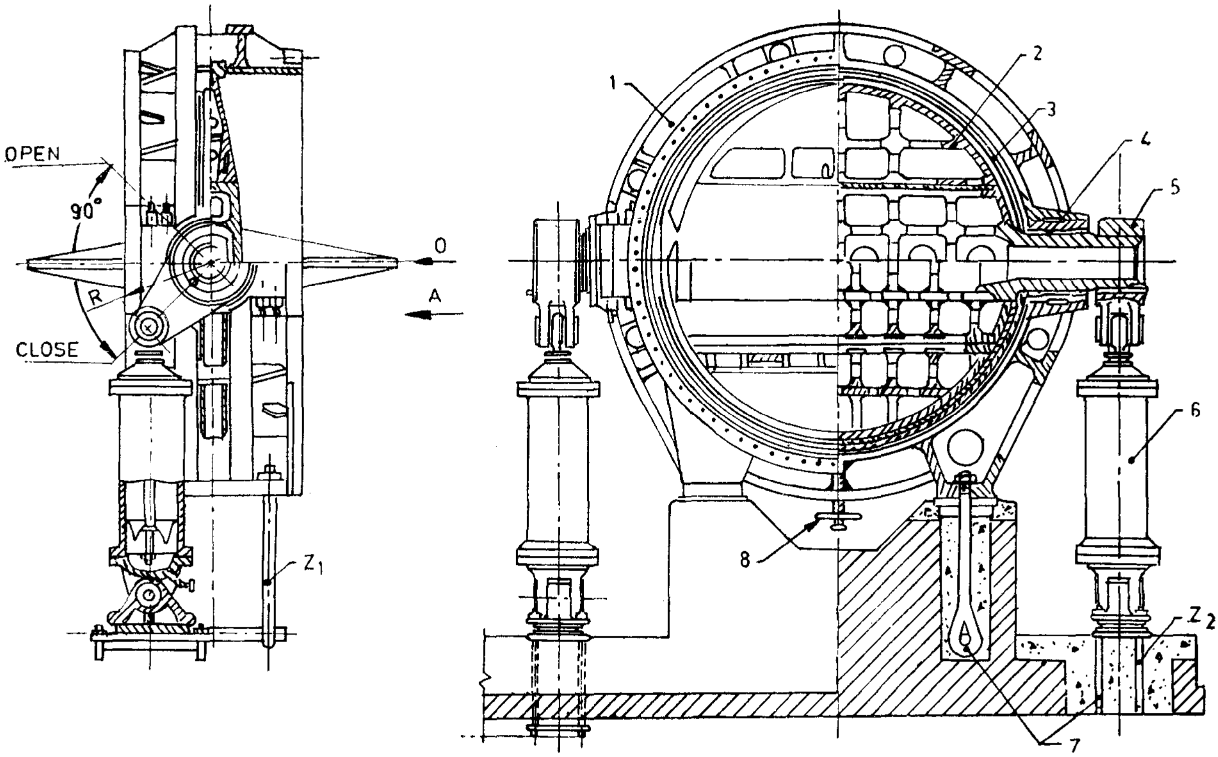
7.6 Seal Seat

Rust resisting seal seat against which sealing ring seats should be securely attached to either the body or the disc. This can be of bolted or welded construction.

7.7 Trunnion Seal

7.7.1 Trunnion seal should be provided on both driving and non-driving trunnions. Its design should be such as to prevent any leakage and to ensure further adjustments and replacement.

7.7.2 Material as recommended in Annex B should be used in its manufacture.



1. Housing
2. Disc
3. Sealing
4. Bearing
5. Levers
6. Servomotors
7. Foundation Bolts
8. Stopper Device

FIG. 1 TYPICAL DETAILS OF BUTTERFLY VALVE — DISC-SYMMETRICAL TYPE

7.8 Dismantling Joint

In order to facilitate dismantling and also for taking care of certain amount of correction of errors in erection suitable dismantling joint should be provided. The dismantling joint may be provided either on upstream side of valve or on downstream side of valve. It can be either rigid type or expansion (flexible) type. The position of the dismantling cum expansion joint whether in upstream or downstream of valve is dependent upon whether the thrust is required to be transmitted downstream of valve or sustained the upstream side by some means.

7.9 Foundations

The valve foundations should be designed to cater for complete tensile and compressive force produced by operating gear occurring during worst conditions of its operation. No hydraulic thrust should be taken on the foundations of the valve when in the closed position. The user should provide suitable means to sustain thrust in the penstock design or on the downstream of the valve (by providing a thrust-collar) if required by the user.

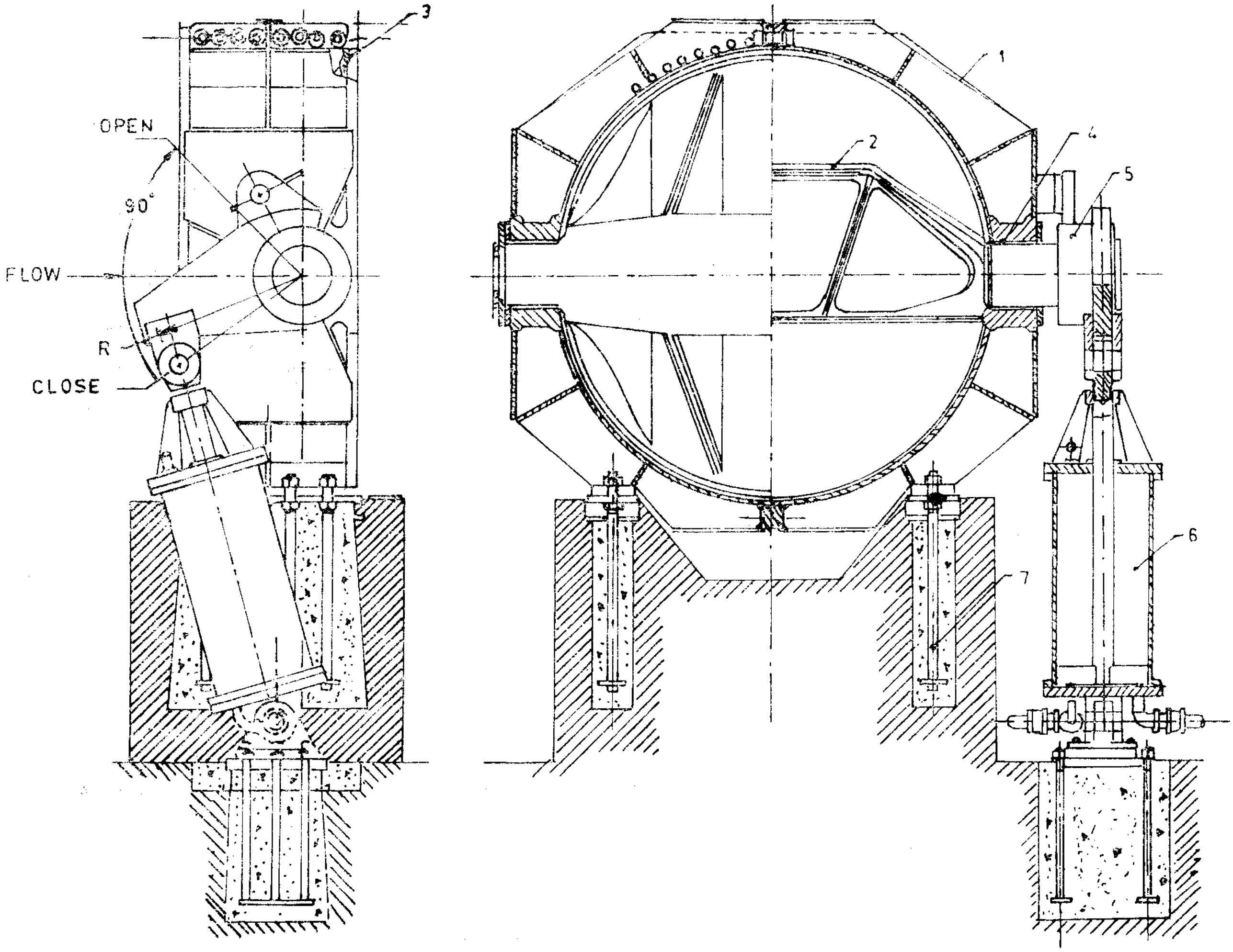
8 TESTING

The tests to be performed after completion of the valve are given in Annex C.

9 SURFACE PREPARATION AND PAINTING

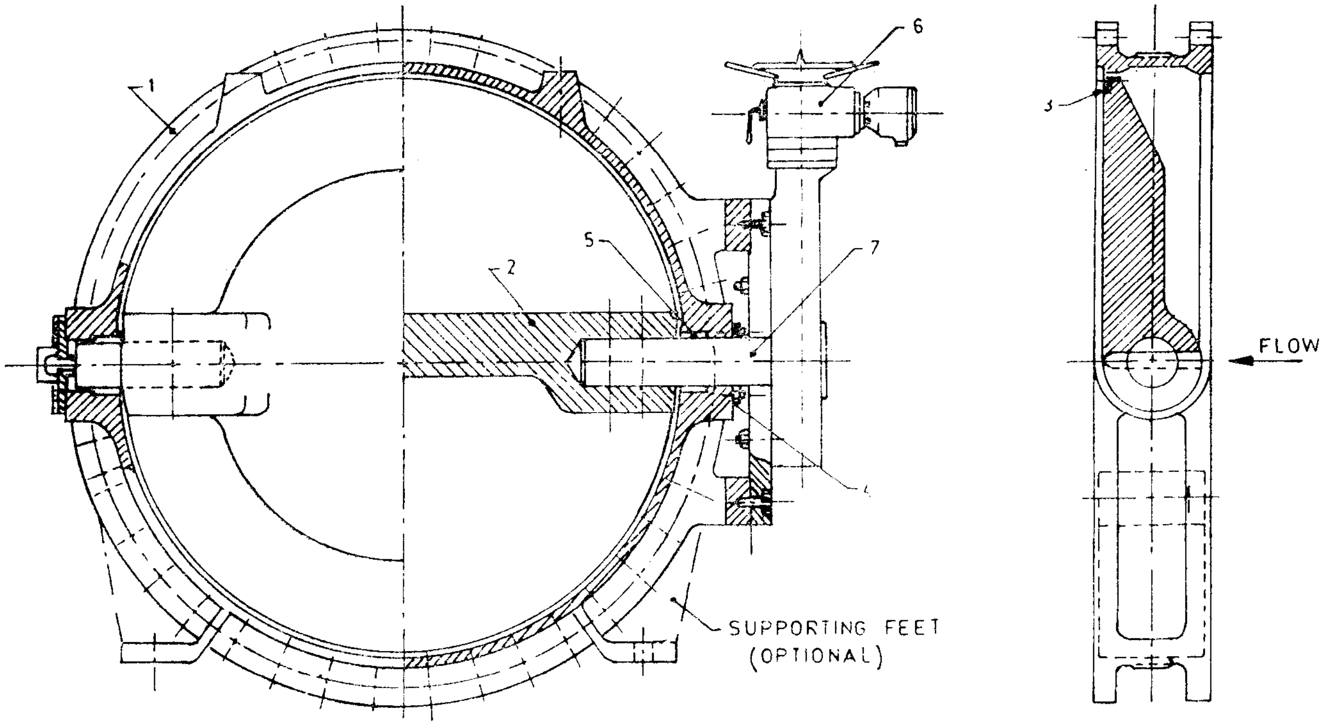
9.1 All unmachined surfaces of ferrous material should be thoroughly cleaned by sand blasting or with wire brushes to base metal to remove all loose scale, graded dust, etc, before they are painted. The painting should consist of two coats of epoxy primer with a minimum DFT of 80 microns followed by 2 coats of coal tar epoxy paint having a minimum DFT of 100 microns on the inside water passage surfaces. The external surfaces should be applied with 2 coats of epoxy primer followed by at least 2 coats of approved epoxy paint.

9.1.1 All material should be carefully boxed, crated or otherwise protected for transportation. Flanges should be protected and exposed and finished surfaces should be thoroughly preserved before transportation.



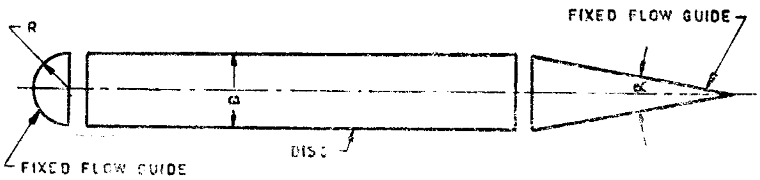
1. Housing
2. Disc
3. Seal
4. Bearing
5. Lever
6. Servomotor
7. Foundation Bolt

FIG. 2 TYPICAL DETAILS OF BUTTERFLY VALVE DISC — LATTICE



1. Housing 2. Disc 3. Seal 4. Thrust Ring
5. Bearing 6. Actuator 7. Trunnion

FIG. 3 TYPICAL DETAILS OF BUTTERFLY VALVE DISC —UNSYMMETRICAL

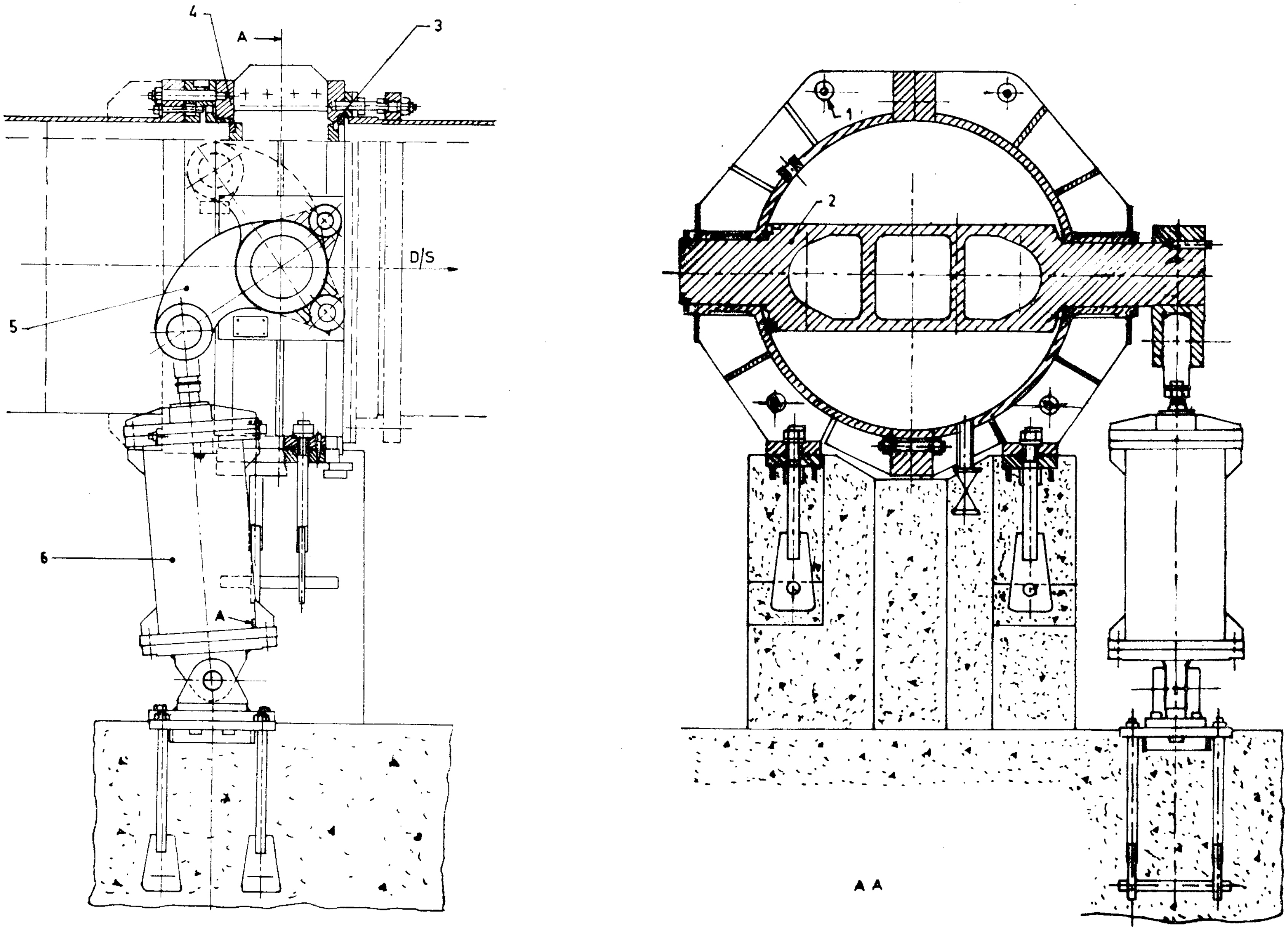


$R = \frac{B}{2}$

$\alpha \leqslant 20°$

B = Thickness of Disc

FIG. 4 TYPICAL DETAILS OF BUTTERFLY VALVE DISC — PARALLEL FACE TYPE



1. Body 2. Door 3. Main Seal
4. Maintenance Seal 5. Lever 6. Servomotor

FIG. 5 BUTTERFLY VALVE DISC — DOUBLE SEAL TYPE

ANNEX A

(*Clause* 2.1)

IS No.	*Title*
28 : 1985	Phosphor bronze ingots and castings (*fourth revision*)
226 : 1975	Structural steel (standard quality) (*fifth revision*)
318 : 1981	Leaded tin bronze ingots and castings (*second revision*)
1030 : 1982	Carbon steel castings for general engineering purposes (*third revision*)
1570 : 1961	Schedules for wrought steels
2002 : 1982	Steel plates for pressure vessels for intermediate and high temperature service including boilers (*first revision*)
2004 : 1978	Carbon steel forgings for general engineering purposes (*second revision*)
2062 : 1984	Weldable structural steel (*third revision*)
2708 : 1984	1·5 percent manganese steel castings for general engineering purposes (*second revision*)
2856 : 1978	Carbon steel castings for pressure containing parts suitable for high temperature service (fusion welding quality) (*third revision*)
6911 : 1972	Stainless steel plate sheet and strip

ANNEX B

(*Clauses* 5.1, 7.1.1, 7.2.1.1, 7.3.1, 7.4.1, 7.5.4 *and* 7.7.2)

RECOMMENDED MATERIALS FOR VARIOUS COMPONENTS

B-1 DETAILS OF MATERIALS

B-1.1 The materials are given below:

a) Valve Body

Mild steel	IS 2002 : 1982, IS 2062 : 1984
Manganese steel	IS 2708 : 1984
Cast Steel	IS 1030 : 1982 or IS 2856 : 1987

b) Valve Disc

Mild Steel	IS 2002 : 1982, IS 2062 : 1984
Manganese steel	IS 2708 : 1984
Cast steel	IS 1030 : 1984 or IS 2856 : 1987

c) Trunnion

Carbon steel	IS 2004 : 1978
High tensile steel	IS 1570 : 1961
Mild steel	IS 2002 : 1982, IS 2062 : 1984 or IS 226 : 1975
Manganese steel	IS 2708 : 1984
Cast steel	IS 1030 : 1982 or IS 2856 : 1987

d) Bushes

Gunmetal	IS 318 : 1981
Bronze	IS 28 : 1985
Self lubricated bushes	

e) 1) Seal — Acrylo nitrile rubber or dilute acid alkali resistant medium hard rubber having a hardness 65°±5° shore or any other resilient material as agreed by the user.

2) Corrosion resistant steel or stainless steel for manually operated upstream maintenance seal.

f) Seal Seat

Stainless steel	IS 6911 : 1972

NOTE — Any other material not mentioned above may be used if agreed between the supplier and the purchaser.

ANNEX C

(*Clause* 8.1)

TESTS TO BE PERFORMED ON THE BUTTERFLY VALVE

C-1 PERFORMANCE TEST

C-1.1 After final assembly, each valve should be shop-operated three times or as agreed by the purchaser from the fully-closed to the fully-open position, and vice versa under no flow condition to demonstrate that the assembly is workable.

C-2 PRESSURE TESTS

C-2.1 All tests should be carried out with water as the test medium but other media may be as agreed by the user.

C-2.2 Each valve should be subjected to the following tests:

a) *Body Tests* — With both ends closed either by full end covers or by hollow cylindrical covers a hydrostatic pressure of one and half times the specified shut-off pressure including pressure rise should be applied. This pressure should be maintained at least for a period of 30 minutes. It should be ensured that there is no leakage through the body or any trunnion seals. The test should reveal that no structural damage is caused.

b) *Disc* — The disc should be hydraulically tested for duration of 30 min for a test pressure of 1 1/2 times the specified shut off pressure including pressure rise. The test should reveal no structural damage or leakage at any point.

c) *Seal Test* — Maximum shut-off pressure should be applied with one end open to the atmosphere and the disc in the closed position. The test should be done for a period of 30 min for maximum shut-off pressure with one end open to the atmosphere and the disc in the closed position.

C-3 PERMISSIBLE LEAKAGES

C-3.1 Maximum permissible leakages from downstream main rubber seal should not exceed 2 litres per minute per meter periphery of seal, when valve is new or reconditioned.

C-3.2 Maximum permissible leakages from upstream maintenance (isolating) seal should not exceed 6 litres per minute per meter periphery of seal.

Standard Mark

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

Bureau of Indian Standards

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